PATENT ABSTRACTS OF JAPAN

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(71)Applicant : NKK CORP
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(54) STAINLESS STEEL SUPERIOR IN HIGH TEMPERATURE STRENGTH AND HOT WORKABILITY

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain stainless steel, high in high-temperature strength, satisfactory in manufacturing yield and cost, and superior in crack resistance in hot working, by containing a specific quantity of C, Si, Mn, S, P, O, Ni, Cr, Al, N, B, Mo, Nb, Ti, V, Zr and Fe.
SOLUTION: The stainless steel contains, in weight %, 0.04-0.15 C, 2 or less Si, 3 or less Mn, 0.003 or less S, 0.07 or less P, 0.004 or less O, 5-25 Ni, 13-35 Cr, 0.006-0.03 At, 0.3 or less N, 0.0002-0.0005 B, and 1.5-4 Mo, and also contains one kind or more from 1.2 or less Nb, 0.6 or less Ti, 0.6 or less V and 1.2 or less Zr, with the balance essentially Fe. The content of B is important; if it is 0.0005 wt.% or less, its improving effect is large on the intergranular strength of the steel to which B is added; if it is in excess of this weight %, cracks are caused at the time of hot rolling depending on slab heating conditions.

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0.04-0.15
≤2
≤3
≤0.07
≤0.003
5-25
13-35
Co
≤0.6
≤1.2
≤0.6
0.0002-0.0005
0.006-0.03
≤0.3
≤0.004
1.5-4

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CLAIMS

[Claim(s)]
[Claim 1] By weight %, C:0.04 - 0.15%, less than [Si:2%], and less than [Mn:3%], S:0.003% or less, P:0.07% or less, and O:0.004% or less, nickel: High temperature strength and stainless steel excellent in hot-working nature which contain 5-25%, Cr:13-35%, aluminum:0.006-0.03%, and N:0.3% or less and B:0.0002 - 0.0005%, and are characterized by consisting of the remainder Fe and an unescapable impurity.
[Claim 2] Stainless steel which was excellent further as a steel component with weight % at the high temperature strength according to claim 1 characterized by containing Mo:1.5-4%, and hot-working nature.
[Claim 3] Stainless steel which was excellent further as a steel component with weight % at the high temperature strength according to claim 1 or 2 characterized by containing more than a kind among less than [Nb:1.2%], less than [Ti:0.6%], V:0.6% or less, and less than [Zr:1.2%], and hot-working nature.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the stainless steel which has the high high temperature strength which can be used for elevated-temperature plant equipment components etc., and was excellent in the hot-working nature at the time of manufacture.
[0002]
[Description of the Prior Art] In recent years, with the advance of steel-manufacture / rolling technique of stainless steel, it is more efficient than before, the cheap stainless steel manufacturing method is developed, and it is well known that the manufacture yield is also improving. especially, it is divided, and in a hot rolling process since the problem of crack generating influences a surface purification load and influences a manufacturing cost greatly, it is boiled variously and examined by cut ends, such as improvement in ductility with working temperature.
[0003] In the case of the austenitic stainless steel of 13% - 35%Cr system which has thermal resistance and high temperature strength, the above-mentioned hot-working nature raises a serious problem. If it becomes what, at 400-800 degrees C which is the service temperature of typical heat-resistant stainless steel it is the weak point of Cr content system iron machine alloy during long duration heating -- a sigma phase, although stabilization of an austenite phase is generally attained by the quality governing with heat-resistant stainless steel in order for a weak intermetallic compound to tend to deposit during an organization and to avoid this If a result to which this decreases or vanishes the minute amount ferrite phase in cast structure is brought and it is in the low austenite of whenever [dissolution / of S, harmful P, harmful O, etc.], it is because extent of the segregation to the grain boundary of these elements is made to rise rapidly and it leads to generating of a remarkable crack.
[0004] In this case, to reduce S, P, O, etc. or to fix to the form of a compound as a design manual from a component side, is set to one of the effective means from a viewpoint of improvement in heat slowing nature. The technique which hammered this out as a component guide of continuous casting material is indicated by JP,60-149748,A. Here, by also reducing S and the amount of O which are segregated to a grain boundary etc. as much as possible shows that the steel plate-proof surface check nature at the time of rolling improves especially by mainly reducing S and O and adding calcium, Ce, and aluminum further. Moreover, contrary to the means of such grain boundary defecation, the reinforcement of the grain boundary itself is raised, the approach which make it hard to be divided is advocated by the addition of an element which is easy to carry out grain boundary segregation, and it is supposed that it is the example of a type of such an element B. According to the technique currently indicated by JP,63-157840,A, by doing B addition of, after restricting a ferrite content, hot-working nature can be raised and it is supposed that JP,5-179405,A has the effectiveness of B addition similarly.
[0005]
[Problem(s) to be Solved by the Invention] However, it is clear from the result of the test pressure total in a production line that the slab by the technique of JP,63-157840,A is hard to be called stable technique which may produce a crack in the phase of slabbing and was suitable for real operation, and evaluation that the effectiveness of B addition lacks stability similarly by the approach by the technique of JP,5-179405,A is being made. Moreover, whether these techniques are not necessarily effective has an unknown point to dimension expansion of the continuous casting slab accompanying enlargement of the structure.
[0006] That is, the purpose of this invention is to offer the stainless steel which has high high temperature strength and was excellent in cracking resistance in hot working for the purpose of reduction of the manufacture yield or a manufacturing cost.

[0007]
[Means for Solving the Problem] In order to solve said technical problem and to attain the purpose, this invention uses the means shown below.
The stainless steel of this invention by weight % (1) C:0.04 - 0.15%, Si: Less than [2%], less than [Mn:3%], S:0.003% or less, and P:0.07% or less, O:0.004% or less, nickel:5-25%, and Cr:13-35%, aluminum: It is the high temperature strength and the stainless steel excellent in hot-working nature which contain 0.006-0.03% and N:0.3% or less and B:0.0002 - 0.0005%, and are characterized by consisting of the remainder Fe and an unescapable impurity.
[0008] (2) The stainless steel of this invention is stainless steel which is characterized by containing Mo:1.5-4% and which was excellent at high temperature strength and hot-working nature given in the above (1) further in weight % as a steel component.
[0009] (3) The stainless steel of this invention is stainless steel which is characterized by containing more than a kind among less than [Nb:1.2%], less than [Ti:0.6%], V:0.6% or less, and less than [Zr:1.2%] and which was excellent at high temperature strength and hot-working nature the above (1) or given in (2) further in weight % as a steel component.
[0010]
[Embodiment of the Invention] this invention persons have checked B repeatedly through the creep rupture test of the various stainless steel which carried out little addition, an elevated temperature tensile test, etc. conventionally about raising grain boundary reinforcement that it is easy to carry out grain boundary segregation of the B. From such knowledge, B is effective ** at the improvement in cracking-resistant at the time of hot working. Nevertheless, this invention persons repeated research wholeheartedly about the cause of not bringing the stable effectiveness to the improvement in cracking-resistant in hot working.
[0011] Consequently, although it was thought that surely B raised grain boundary reinforcement, the melting point near a grain boundary was reduced to coincidence, and promoting melting at the time of heating of steel as a result was found out. That is, the crack produced in the phase of slabbing at the time of real manufacture is that the part (grain boundary) which reached the melting point partially loses ductility, and it became clear to have caused the processing crack. That is, as a factor of a crack, it will be influenced [all] as a temperature factor of extent of a segregation, extent of the melting point fall which local component fluctuation brings about, extent of a distortion local as a processing factor, etc. as the effect of the temperature distribution in slab, processing generation of heat, etc. depending on the heating temperature of a furnace, and a slab dimension, and an ingredient factor.
[0012] Among these, when it was less than [that segregation of the local distortion as an ingredient factor or extent of concentration amounts to about 10 or more times of an average presentation in B therefore that the amount of B as an average presentation should make an upper limit 0.0005% of the weight of addition, and this], the remarkable thing has checked clearly the improvement effectiveness of the grain boundary reinforcement of B addition steel which artificers have checked conventionally. And in the technique to precede, it came to check that the addition of B arises, and the crack has all arisen depending on slab heating conditions at the time of hot rolling since it is abundant, 0.0005% or more and.
[0013] Based on the above knowledge, as this invention persons are the range which does not degrade the hot-working nature and controlled the amount of B added to austenitic stainless steel within fixed limits, they completed a header and this invention for the stainless steel excellent in high temperature strength and hot-working nature.
[0014] That is, this invention can offer the stainless steel which has high high temperature strength and was excellent in cracking resistance in hot working for the purpose of reduction of the manufacture yield or a manufacturing cost by limiting a steel presentation to the following range.
[0015] The reason for component addition and the reason for component limitation of this invention are explained below.
(1) Since sufficient improvement in high temperature strength is not obtained unless it adds 0.04% or more, but heat slowing nature will be injured on the other hand if it adds exceeding 0.15% although it is the element which is useful to the improvement in grain boundary on the strength of the component presentation range steel of C:0.04 - 0.15%, and raises high temperature strength, an addition is 0.04 - 0.15%.
[0016] Si: Although effectiveness is in deoxidation 2% or less and hot-working nature is raised through O reduction in steel, since the cracks after rolling will come to occur frequently if it adds exceeding 2%, an

addition is 2% or less.
[0017] Mn: Although it works effectively as an austenite stabilization element in stainless steel 3% or less, since ductility will fall if it adds exceeding 3%, an addition is 3% or less.
[0018] It is the element most harmful to S:0.003% or less hot-working nature, and a content is so good that it is low. Since heat slowing nature is permissible if it is 0.003% or less, a content is 0.003% or less.
[0019] It is the element which injures hot-working nature P:0.07% or less, and a content is so good that it is low. Since heat slowing nature is permissible if it is 0.07% or less, a content is 0.07% or less.
[0020] It is the element which injures hot-working nature O:0.004% or less, and a content is so good that it is low. Since heat slowing nature is permissible if it is 0.004% or less, a content is 0.004% or less.
[0021] nickel: -- it is the stabilization element of an austenite phase powerful 5 to 25%, and the ductility of steel is raised generally. By the target component system, 5% or more needs to be added for stabilization of an inphase here. On the other hand, since an inphase will become too stable, extent of the grain boundary segregation of elements, such as S, harmful P, harmful O, etc., will become remarkably large and it will result in spoiling hot-working nature if it adds exceeding 25%, an addition is 5 - 25%.
[0022] Cr: It is the fundamental component of 13 - 35% stainless steel, and is effective on a hot anti-oxidation disposition. If it does not add 13% or more, as a result of there being scale at the time of heating at high temperature along a grain boundary and developing into the interior remarkably, the crack at the time of hot working will also become remarkable. On the other hand, if it adds exceeding 35%, since it will become difficult to hold an organization in austenite single phase and it will become easy to generate the crack at the time of processing too in an interface with the ferrite phase which deposited, an addition is 13 - 35%.
[0023] aluminum: Although effectiveness is in deoxidation like Si 0.006 to 0.03% and hot-working nature is raised through O reduction in steel, since the streak flaws after rolling will come to occur frequently if effectiveness is not enough unless it adds 0.006% or more, and it adds exceeding 0.03% conversely, an addition is 0.006 - 0.03%.
[0024] An austenite phase is stable N:0.3% or less with addition. Since an inphase will become too stable, extent of the grain boundary segregation of elements, such as S, harmful P, harmful O, etc., will become remarkably large and it will result in spoiling hot-working nature if it is the same as that of the case of nickel and adds exceeding 0.3%, an addition is 0.3% or less.
[0025] Control of an addition is just going to consider as the chief aim of this invention as mentioned above B:0.0002 to 0.0005%. Although the content contained as an impurity in the usual steel manufacture is about 0.0001%, the effectiveness of 0.0002% or more of content, then crystal stressing shows up enough. On the other hand, if contained exceeding 0.0005%, since it will become easy to produce the compound of the low melting point in a grain boundary and a crack will be produced depending on heating conditions at the time of rolling, a content is restricted to 0.0002 - 0.0005%.
[0026] Mo: 1.5% or more which is an element effective in the corrosion-resistant improvement in steel and by which the effectiveness is demonstrated 1.5 to 4%, it is 4% or less of range which the crack at the time of rolling by the self-segregation does not generate, and selection addition is possible.
[0027] Since each of Nb(s), and Ti, V and Zr form carbide powerfully Zr<=1.2% and the high temperature strength of steel is raised rather than the case where C is only added, through carbide dispersion strengthening Nb<=1.2%, Ti<=0.6%, and V<=0.6%, the selection addition even of the four kinds can be carried out more than a kind. If it adds exceeding 1.2%, 0.6%, 0.6%, and 1.2%, respectively, since an intermetallic compound harmful at the time of heating use will generate and high temperature strength will be reduced, an addition is less than [Zr:1.2%] less than [Nb:1.2%], less than [Ti:0.6%], and V:0.6% or less.
[0028] By adjusting to the above-mentioned component presentation range, it becomes possible to obtain the stainless steel excellent in high temperature strength and hot-working nature. In addition, about manufacture conditions, it is not limited especially by this invention. Namely, the ingot approach of stainless steel, the rolling approach at the time of steel plate manufacture, and the heat treatment approaches should just be conditions usually adopted. The example of this invention is given to below and the effectiveness of this invention is proved.
[0029]
[Example] Table 1 makes the chemical entity, high temperature strength, and hot-working nature (at the time of rolling the surface crack number, lug crack die length) of comparison steel (No.33-61) this invention steel (No.1-32), and Table 2 makes them a list.

[0030] Experimental reactor vacuum melting of each steel was carried out, and it used the obtained steel ingot as sample offering steel according to the process of 1250-degree-C heating slabbing and finishing rolling, and annealing. Slabbing evaluated hot-working nature by considering as 20% or more of large pressing-down rolling 3 pass, and carrying out direct observation of the front face/the end face of the slab after rolling. That is, the surface crack including a streak flaw was counted focusing on the slab latest section, and was evaluated as the crack number per unit surface area, and the lug crack and edge crack die length further produced at the edge were measured as the depth from an edge.

[0031] About high temperature strength, at a broth (diameter [of the parallel part dimension of 6mm] x30mm die length), and 600 degrees C, the creep rupture test piece was deleted from the plate center section after finishing rolling in the direction of L, and the creep rupture trial of 2-several was carried out, and it interpolated or extrapolated and asked for fracture strength for 1000 hours.

[0032] This invention steel No.1-No.32 are excellent in good high temperature strength and coincidence a pressure-proof total at hot-working nature, such as crack nature, compared with the comparison steel mentioned later. these -- receiving -- comparison steel No.34 -- C and comparison steel No.35 -- Si and comparison steel No.36 -- Mn and comparison steel No.37 -- P and comparison steel No.39 -- O and comparison steel No.41 -- nickel and comparison steel No.43 -- Cr and comparison steel No. -- the content of 46 andN has exceeded the range of this invention default value, and 54 are inferior in hot-working nature as compared with this invention steel. Moreover, when the content of B has exceeded the range of this invention default value like comparison steel No.47, and 55 and 56, while a lug crack increases, it also turns out that lack arises to heat slowing nature too only by additive-free impurity level being included like comparison steel No.48. The relation between B content and lug crack die length is shown in drawing 1 .

[0033] On the other hand, comparison steel No.33 run short of C, and good high temperature strength is not obtained. Comparison steel No.38 have the superfluous content of S, and as compared with this invention steel, high temperature strength is inferior in them too as a result of the fall of elevated-temperature ductility of long duration. Moreover, comparison steel No.40 run short of the amounts of nickel, and an organization does not become an austenite, but high temperature strength is low. Comparison steel No.42 caused promotion of a ruptured, as a result of the amounts of Cr(s) running short and receiving high temperature oxidation with a remarkable creep rupture test piece front face. Naturally, high temperature strength is low. It Nb(s). comparison steel No.49 [furthermore,] -- Mo and comparison steel No. -- 50 and 57 comparison steel No. -- 51 and 58 -- Ti and comparison steel No. -- 52, 59V, and comparison steel No. -- 53 and 60 -- Zr -- As a result of the content of Nb and Ti having exceeded the range of this invention default value and causing self-segregation or a deposit of a weak intermetallic compound, as compared with this invention steel, hot-working nature or high temperature strength is inferior in comparison steel No.61. comparison steel No. -- since 44 and 45 had the respectively insufficient or superfluous amount of aluminum, in lug crack generating and the latter which are depended insufficiently [the former / deoxidation], streak flaw increase of an oxide reason was conspicuous. The streak flaw number also increases sharply the case of the above-mentioned overSi of comparison steel No.35, and overO of comparison steel No.39, and it is presumed that it is an oxide reason.

[0034] Taking correspondence with the above laboratory examination, it carried out about 6 charge and the prototype of a real production line evaluated hot-working nature (manufacturability) about two items of high temperature strength, and a surface crack and a lug crack. A result is collectively shown in Table 3. In No.70 of Table 3, No.71, and No.72, this invention steel, No.73, No.74, and No.75 are comparison steel.

[0035] Each this invention steel No.70-72 has good high temperature strength, and a surface crack is five pieces/m2. It was the following and the lug crack was the level which is 5mm or less and can carry out care-and-cleaning removal easily from an edge.

[0036] On the other hand, more greatly [the amount of B] than the fitness range, since comparison steel No.74 were lower than the fitness range, as for all, many surface cracks arose and the lug crack also had [comparison steel No.73] a deep inclination. The relation between the amount of B and lug crack die length is shown in drawing 2 . Furthermore, since comparison steel No.75 have the amount of C lower than the fitness range, high temperature strength is inferior in them.

[0037] In addition, 6 charges of real manufacture used the slab cross section of 250x1700 (mm) by the large-sized continuous casting machine system-ized recently. In order to obtain the hot-working nature and high temperature strength which are meant by this invention so that it may illustrate above, he specifies the content of each alloy element by which it is characterized by this invention, and it is understood that it is required to

manage especially the amount of B strictly.

[0038]

[Table 1]

表 1

区分	No.	化学成分 (重量%)								
		C	Si	Mn	P	S	O	Ni	Cr	sol. Al
本発明鋼	1	0.05	0.59	1.25	0.036	0.002	0.0030	8.42	17.85	0.011
	2	0.04	0.65	1.04	0.028	0.002	0.0025	10.52	18.06	0.008
	3	0.14	0.51	1.08	0.022	0.001	0.0028	8.30	18.11	0.009
	4	0.06	1.70	1.34	0.030	0.001	0.0027	8.09	18.04	0.010
	5	0.05	0.44	2.51	0.019	0.001	0.0024	7.95	18.10	0.007
	6	0.05	0.65	1.26	0.065	0.002	0.0021	12.03	18.24	0.007
	7	0.05	0.60	1.15	0.015	0.003	0.0019	12.05	18.09	0.009
	8	0.08	0.53	1.10	0.016	0.002	0.0040	11.55	18.13	0.009
	9	0.05	0.58	1.34	0.022	0.003	0.0033	6.00	16.19	0.018
	10	0.07	0.57	1.19	0.041	0.001	0.0035	23.20	17.96	0.016
	11	0.05	0.46	1.23	0.036	0.002	0.0030	5.68	14.82	0.022
	12	0.07	0.64	1.20	0.033	0.001	0.0028	21.00	25.30	0.019
	13	0.07	0.47	1.55	0.032	0.002	0.0027	24.30	32.90	0.025
	14	0.06	0.52	1.02	0.027	0.002	0.0015	9.42	17.82	0.006
	15	0.06	0.55	1.18	0.026	0.001	0.0011	9.31	17.80	0.029
	16	0.05	0.55	1.07	0.040	0.002	0.0033	9.38	17.96	0.014
	17	0.06	0.61	1.07	0.024	0.002	0.0036	8.99	17.93	0.012
	18	0.05	0.67	1.03	0.016	0.001	0.0034	8.76	17.88	0.011
	19	0.05	0.59	1.10	0.033	0.001	0.0032	8.80	17.69	0.017
	20	0.06	0.58	1.28	0.035	0.001	0.0039	12.04	18.03	0.015
	21	0.07	0.69	1.27	0.031	0.002	0.0024	11.68	18.00	0.020
	22	0.06	0.81	1.24	0.030	0.001	0.0035	11.84	18.01	0.016
	23	0.07	0.82	1.25	0.026	0.002	0.0034	11.37	18.10	0.017
	24	0.07	0.44	1.33	0.025	0.001	0.0029	10.06	18.27	0.013
	25	0.05	0.49	1.36	0.020	0.001	0.0026	10.38	17.68	0.023
	26	0.06	0.55	1.15	0.031	0.002	0.0017	8.25	18.01	0.019
	27	0.05	0.47	1.04	0.019	0.002	0.0026	8.33	18.06	0.012
	28	0.06	0.44	1.09	0.017	0.001	0.0015	8.46	18.10	0.009
	29	0.06	0.39	1.07	0.026	0.001	0.0030	8.31	18.04	0.008
	30	0.07	0.36	1.03	0.022	0.001	0.0017	8.72	18.05	0.016
	31	0.06	0.48	1.08	0.025	0.003	0.0018	8.99	18.07	0.017
	32	0.06	0.47	1.11	0.024	0.002	0.0022	8.62	17.89	0.014

[0039]

[Table 2]

表　1（つづき）

区分	No.	化学成分（重量%）						
		N	B	Mo	Nb	Ti	V	Zr
本発明鋼	1	0.007	0.0004	0.04	0.00	0.00	0.00	0.00
	2	0.003	0.0002	0.03	0.00	0.00	0.00	0.00
	3	0.004	0.0003	0.03	0.00	0.00	0.00	0.00
	4	0.011	0.0005	0.02	0.00	0.00	0.00	0.00
	5	0.009	0.0004	0.02	0.00	0.00	0.00	0.00
	6	0.008	0.0004	0.02	0.00	0.00	0.00	0.00
	7	0.010	0.0005	0.03	0.00	0.00	0.00	0.00
	8	0.007	0.0002	0.03	0.00	0.00	0.00	0.00
	9	0.009	0.0002	0.04	0.00	0.00	0.00	0.00
	10	0.014	0.0003	0.03	0.00	0.00	0.00	0.00
	11	0.012	0.0005	0.04	0.00	0.00	0.00	0.00
	12	0.011	0.0005	2.40	0.00	0.00	0.00	0.00
	13	0.006	0.0004	2.40	0.00	0.00	0.00	0.00
	14	0.008	0.0003	2.40	0.00	0.00	0.00	0.00
	15	0.010	0.0004	0.04	0.00	0.00	0.00	0.00
	16	0.244	0.0004	0.05	0.00	0.00	0.00	0.00
	17	0.154	0.0005	0.03	0.00	0.00	0.00	0.00
	18	0.162	0.0005	0.02	0.00	0.00	0.00	0.00
	19	0.002	0.0005	0.04	0.00	0.00	0.00	0.00
	20	0.006	0.0005	1.80	0.00	0.00	0.00	0.00
	21	0.004	0.0003	2.43	0.00	0.00	0.00	0.00
	22	0.008	0.0004	3.56	0.00	0.00	0.00	0.00
	23	0.003	0.0004	0.05	0.87	0.00	0.00	0.00
	24	0.007	0.0003	0.04	0.00	0.44	0.00	0.00
	25	0.002	0.0002	0.03	0.00	0.00	0.39	0.00
	26	0.006	0.0004	0.05	0.00	0.00	0.00	0.65
	27	0.001	0.0004	0.34	0.21	0.15	0.00	0.00
	28	0.004	0.0003	2.43	0.74	0.00	0.00	0.00
	29	0.003	0.0002	2.48	0.51	0.38	0.00	0.00
	30	0.002	0.0003	2.36	0.44	0.00	0.21	0.00
	31	0.002	0.0005	2.39	0.26	0.25	0.12	0.00
	32	0.005	0.0004	2.51	0.34	0.20	0.14	0.37

[0040]
[Table 3]

表　1（つづき）

区分	No.	高温強度	圧延時表面疵	圧延時耳割れ
		600℃1000hクリープ破断強さ（MPa）	疵個数（個／m^2）	エッジからの深さ（mm）
本発明鋼	1	205	4	0.0
	2	184	4	0.0
	3	268	0	0.0
	4	197	2	0.0
	5	186	1	0.0
	6	245	3	0.0
	7	203	3	0.0
	8	200	7	0.0
	9	172	0	0.0
	10	228	4	0.0
	11	174	2	0.5
	12	231	3	0.0
	13	213	0	0.3
	14	210	0	0.0
	15	218	4	0.0
	16	324	1	0.0
	17	306	0	0.0
	18	308	0	0.0
	19	234	2	0.0
	20	227	0	0.0
	21	263	0	0.0
	22	266	3	0.0
	23	310	0	0.0
	24	295	2	0.0
	25	275	5	0.0
	26	260	0	0.0
	27	315	1	0.0
	28	322	4	0.0
	29	330	0	0.0
	30	301	3	0.0
	31	316	0	0.0
	32	289	0	0.0

[0041]
[Table 4]

表　2

区分	No	化学成分（重量%）								
		C	Si	Mn	P	S	O	Ni	Cr	sol. Al
比較鋼	33	0.03*	0.55	1.07	0.024	0.001	0.0026	8.23	17.45	0.011
	34	0.17*	0.57	1.24	0.026	0.001	0.0031	8.45	18.02	0.008
	35	0.07	2.4*	1.13	0.023	0.001	0.0021	8.16	18.87	0.009
	36	0.06	0.89	3.84*	0.041	0.002	0.0019	8.17	19.03	0.010
	37	0.06	0.91	1.16	0.102*	0.001	0.0017	8.20	18.11	0.007
	38	0.07	0.68	1.09	0.039	0.005*	0.0028	10.65	17.36	0.007
	39	0.06	0.67	1.06	0.028	0.002	0.0140*	10.10	17.94	0.009
	40	0.05	0.60	1.08	0.027	0.002	0.0031	3.55*	18.10	0.009
	41	0.05	0.62	1.08	0.019	0.001	0.0017	25.50*	18.52	0.018
	42	0.05	0.59	1.17	0.014	0.001	0.0027	10.04	11.05*	0.016
	43	0.04	0.63	1.22	0.026	0.003	0.0027	25.00	35.51*	0.022
	44	0.07	0.66	1.27	0.029	0.003	0.0026	10.13	17.89	0.004*
	45	0.06	0.67	1.23	0.035	0.001	0.0028	9.35	17.25	0.044*
	46	0.08	0.65	1.20	0.037	0.001	0.0030	9.33	17.88	0.006
	47	0.06	0.54	1.02	0.030	0.003	0.0014	9.41	18.14	0.029
	48	0.05	0.53	1.11	0.020	0.002	0.0018	9.50	18.26	0.014
	49	0.05	0.48	1.17	0.018	0.002	0.0029	9.28	18.75	0.012
	50	0.07	0.57	1.13	0.028	0.002	0.0027	12.03	17.34	0.011
	51	0.06	0.55	1.05	0.036	0.001	0.0011	12.04	17.55	0.017
	52	0.07	0.53	1.09	0.037	0.002	0.0030	12.05	18.65	0.015
	53	0.07	0.52	1.50	0.027	0.001	0.0025	12.01	19.12	0.020
	54	0.06	0.59	1.03	0.029	0.002	0.0023	12.18	21.03	0.016
	55	0.05	0.51	1.14	0.021	0.001	0.0021	12.16	20.00	0.017
	56	0.06	0.48	1.47	0.025	0.001	0.0013	12.04	23.05	0.013
	57	0.06	0.53	1.25	0.038	0.001	0.0018	12.07	18.03	0.023
	58	0.07	0.60	1.00	0.037	0.002	0.0027	12.05	18.47	0.019
	59	0.06	0.49	1.03	0.018	0.002	0.0025	10.35	17.44	0.012
	60	0.07	0.51	0.97	0.017	0.002	0.0025	9.30	16.59	0.009
	61	0.07	0.57	1.90	0.017	0.001	0.0016	8.31	16.23	0.008

注）＊印は本発明の範囲から外れていることを表す。

[0042]
[Table 5]

表　2（つづき）

区分	No.	化学成分（重量%）						
		N	B	Mo	Nb	Ti	V	Zr
比較鋼	33	0.005	0.0002	0.03	0.00	0.00	0.00	0.00
	34	0.004	0.0003	0.02	0.00	0.00	0.00	0.00
	35	0.003	0.0003	0.03	0.00	0.00	0.00	0.00
	36	0.009	0.0005	0.04	0.00	0.00	0.00	0.00
	37	0.011	0.0004	0.03	0.00	0.00	0.00	0.00
	38	0.010	0.0003	0.03	0.00	0.00	0.00	0.00
	39	0.006	0.0002	0.03	0.00	0.00	0.00	0.00
	40	0.004	0.0004	0.02	0.00	0.00	0.00	0.00
	41	0.010	0.0004	0.04	0.00	0.00	0.00	0.00
	42	0.016	0.0004	0.04	0.00	0.00	0.00	0.00
	43	0.014	0.0003	0.03	0.00	0.00	0.00	0.00
	44	0.007	0.0005	0.03	0.00	0.00	0.00	0.00
	45	0.008	0.0004	0.02	0.00	0.00	0.00	0.00
	46	0.320*	0.0003	0.03	0.00	0.00	0.00	0.00
	47	0.016	0.0009*	0.04	0.00	0.00	0.00	0.00
	48	0.020	0.0001*	0.03	0.00	0.00	0.00	0.00
	49	0.009	0.0005	4.5*	0.00	0.00	0.00	0.00
	50	0.003	0.0005	0.01	1.25*	0.00	0.00	0.00
	51	0.007	0.0003	0.02	0.00	0.75*	0.00	0.00
	52	0.006	0.0004	0.01	0.00	0.00	0.77*	0.00
	53	0.002	0.0002	0.03	0.00	0.00	0.00	1.43*
	54	0.315*	0.0003	2.32	0.00	0.00	0.00	0.00
	55	0.016	0.0034*	2.41	0.00	0.00	0.00	0.00
	56	0.013	0.0017*	2.40	0.00	0.00	0.00	0.00
	57	0.021	0.0003	2.36	1.22*	0.00	0.00	0.00
	58	0.007	0.0002	2.28	0.00	0.68*	0.00	0.00
	59	0.004	0.0004	2.35	0.00	0.00	0.72*	0.00
	60	0.005	0.0003	2.20	0.00	0.00	0.00	1.35*
	61	0.009	0.0002	2.14	1.29*	0.77*	0.00	0.00

注）＊印は本発明の範囲から外れていることを表す。

[0043]
[Table 6]

表　2（つづき）

区分	No.	高温強度	圧延時表面疵	圧延時耳割れ
		600℃1000hクリープ破断強さ (MPa)	疵個数 (個/m^2)	エッジからの深さ (mm)
比較鋼	33	134*	2	0.0
	34	234	3	5.3
	35	203	84	1.3
	36	178	1	2.2
	37	243	0	2.9
	38	146*	0	4.0
	39	198	29	1.8
	40	147*	3	0.0
	41	210	0	3.2
	42	133*	2	10.7
	43	206	3	3.3
	44	211	0	1.6
	45	215	57	1.0
	46	343	3	3.8
	47	228	0	2.0
	48	254	1	1.6
	49	260	3	2.9
	50	142*	2	0.0
	51	138*	2	0.0
	52	110*	0	0.0
	53	117*	4	0.0
	54	304	6	4.1
	55	249	2	3.7
	56	241	2	2.6
	57	139*	3	0.0
	58	115*	0	0.0
	59	116*	0	0.0
	60	108*	4	0.0
	61	103*	0	0.0

注）＊印は標準的な本発明鋼より５０ＭＰａ以上低強度であることを表す。

[0044]
[Table 7]

表　3

区分	No.	化学成分 (重量%)								
		C	Si	Mn	P	S	O	Ni	Cr	sol.Al
本発明鋼	70	0.12	0.50	1.02	0.025	0.001	0.0033	8.21	18.07	0.008
	71	0.06	1.45	1.00	0.021	0.001	0.0034	8.10	18.05	0.009
	72	0.05	0.43	1.68	0.020	0.002	0.0040	8.08	18.03	0.008
比較鋼	73	0.05	0.51	1.00	0.032	0.002	0.0029	8.06	18.10	0.009
	74	0.04	0.50	1.12	0.028	0.003	0.0041	8.01	18.07	0.009
	75	0.02*	0.52	1.04	0.019	0.001	0.0040	8.03	18.11	0.012

注）＊印は本発明の範囲から外れていることを表す。

[0045]
[Table 8]

表　3（つづき）

区　分	No	化　学　成　分　（重量%）						
		N	B	Mo	Nb	Ti	V	Zr
本発明鋼	70	0.005	0.0005	0.05	0.00	0.00	0.00	0.00
	71	0.009	0.0003	0.03	0.00	0.00	0.00	0.00
	72	0.007	0.0003	0.03	0.00	0.00	0.00	0.00
比較鋼	73	0.006	0.0010*	0.02	0.00	0.00	0.00	0.00
	74	0.015	0.0001*	0.02	0.00	0.00	0.00	0.00
	75	0.008	0.0004	0.03	0.00	0.00	0.00	0.00

注）＊印は本発明の範囲から外れていることを表す。

[0046]
[Table 9]

表　3（つづき）

区　分	No	高温強度	圧延時表面疵	圧延時耳割れ
		600 ℃×1000時間 ｸﾘｰﾌﾟ破断強さ（MPa）	疵個数（個／m^2）	ｴｯｼﾞからの深さ（mm）
本発明鋼	70	280	1	0.0
	71	203	4	0.0
	72	179	3	0.0
比較鋼	73	236	6 *	6.0 *
	74	238	15 *	5.5 *
	75	120 *	4	0.0

注）＊印は本発明の範囲から外れていることを表す。

[0047]
[Effect of the Invention] As explained above, according to this invention, by specifying a steel presentation, the conventional technique is more large-sized than the target slab cross section, also in conditions severe to hot-rolling workability, the stainless steel which was excellent in hot-working nature can be offered, having high high temperature strength, and useful effectiveness is brought about on industry through the manufacture yield, reduction of a manufacturing cost, etc.

[Translation done.]

* NOTICES *

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2.**** shows the word which can not be translated.
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TECHNICAL FIELD

[Field of the Invention] This invention relates to the stainless steel which has the high high temperature strength which can be used for elevated-temperature plant equipment components etc., and was excellent in the hot-working nature at the time of manufacture.

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PRIOR ART

[Description of the Prior Art] In recent years, with the advance of steel-manufacture / rolling technique of stainless steel, it is more efficient than before, the cheap stainless steel manufacturing method is developed, and it is well known that the manufacture yield is also improving. especially, it is divided, and in a hot rolling process since the problem of crack generating influences a surface purification load and influences a manufacturing cost greatly, it is boiled variously and examined by cut ends, such as improvement in ductility with working temperature.

[0003] In the case of the austenitic stainless steel of 13% - 35%Cr system which has thermal resistance and high temperature strength, the above-mentioned hot-working nature raises a serious problem. At 400-800 degrees C which will be the service temperature of typical heat-resistant stainless steel if it becomes what it is the weak point of Cr content system iron machine alloy during long duration heating -- a sigma phase, although stabilization of an austenite phase is generally attained by the quality governing with heat-resistant stainless steel in order for a weak intermetallic compound to tend to deposit during an organization and to avoid this If a result to which this decreases or vanishes the minute amount ferrite phase in cast structure is brought and it is in the low austenite of whenever [dissolution / of S, harmful P, harmful O, etc.], it is because extent of the segregation to the grain boundary of these elements is made to rise rapidly and it leads to generating of a remarkable crack.

[0004] In this case, to reduce S, P, O, etc. or to fix to the form of a compound as a design manual from a component side, is set to one of the effective means from a viewpoint of improvement in heat slowing nature. The technique which hammered this out as a component guide of continuous casting material is indicated by JP,60-149748,A. Here, by also reducing S and the amount of O which are segregated to a grain boundary etc. as much as possible shows that the steel plate-proof surface check nature at the time of rolling improves especially by mainly reducing S and O and adding calcium, Ce, and aluminum further. Moreover, contrary to the means of such grain boundary defecation, the reinforcement of the grain boundary itself is raised, the approach which make it hard to be divided is advocated by the addition of an element which is easy to carry out grain boundary segregation, and it is supposed that it is the example of a type of such an element B. According to the technique currently indicated by JP,63-157840,A, by doing B addition of, after restricting a ferrite content, hot-working nature can be raised and it is supposed that JP,5-179405,A has the effectiveness of B addition similarly.

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EFFECT OF THE INVENTION

[Effect of the Invention] As explained above, according to this invention, by specifying a steel presentation, the conventional technique is more large-sized than the target slab cross section, also in conditions severe to hot-rolling workability, the stainless steel which was excellent in hot-working nature can be offered, having high high temperature strength, and useful effectiveness is brought about on industry through the manufacture yield, reduction of a manufacturing cost, etc.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, it is clear from the result of the test pressure total in a production line that the slab by the technique of JP,63-157840,A is hard to be called stable technique which may produce a crack in the phase of slabbing and was suitable for real operation, and evaluation that the effectiveness of B addition lacks stability similarly by the approach by the technique of JP,5-179405,A is being made. Moreover, whether these techniques are not necessarily effective has an unknown point to dimension expansion of the continuous casting slab accompanying enlargement of the structure.
[0006] That is, the purpose of this invention is to offer the stainless steel which has high high temperature strength and was excellent in cracking resistance in hot working for the purpose of reduction of the manufacture yield or a manufacturing cost.

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MEANS

[Means for Solving the Problem] In order to solve said technical problem and to attain the purpose, this invention uses the means shown below.
The stainless steel of this invention by weight % (1) C:0.04 - 0.15%, Si: Less than [2%], less than [Mn:3%], S:0.003% or less, and P:0.07% or less, O:0.004% or less, nickel:5-25%, and Cr:13-35%, aluminum: It is the high temperature strength and the stainless steel excellent in hot-working nature which contain 0.006-0.03% and N:0.3% or less and B:0.0002 - 0.0005%, and are characterized by consisting of the remainder Fe and an unescapable impurity.
[0008] (2) The stainless steel of this invention is stainless steel which is characterized by containing Mo:1.5-4% and which was excellent at high temperature strength and hot-working nature given in the above (1) further in weight % as a steel component.
[0009] (3) The stainless steel of this invention is stainless steel which is characterized by containing more than a kind among less than [Nb:1.2%], less than [Ti:0.6%], V:0.6% or less, and less than [Zr:1.2%] and which was excellent at high temperature strength and hot-working nature the above (1) or given in (2) further in weight % as a steel component.
[0010]
[Embodiment of the Invention] this invention persons have checked B repeatedly through the creep rupture test of the various stainless steel which carried out little addition, an elevated temperature tensile test, etc. conventionally about raising grain boundary reinforcement that it is easy to carry out grain boundary segregation of the B. From such knowledge, B is effective ** at the improvement in cracking-resistant at the time of hot working. Nevertheless, this invention persons repeated research wholeheartedly about the cause of not bringing the stable effectiveness to the improvement in cracking-resistant in hot working.
[0011] Consequently, although it was thought that surely B raised grain boundary reinforcement, the melting point near a grain boundary was reduced to coincidence, and promoting melting at the time of heating of steel as a result was found out. That is, the crack produced in the phase of slabbing at the time of real manufacture is that the part (grain boundary) which reached the melting point partially loses ductility, and it became clear to have caused the processing crack. That is, as a factor of a crack, it will be influenced [all] as a temperature factor of extent of a segregation, extent of the melting point fall which local component fluctuation brings about, extent of a distortion local as a processing factor, etc. as the effect of the temperature distribution in slab, processing generation of heat, etc. depending on the heating temperature of a furnace, and a slab dimension, and an ingredient factor.
[0012] Among these, when it was less than [that segregation of the local distortion as an ingredient factor or extent of concentration amounts to about 10 or more times of an average presentation in B therefore that the amount of B as an average presentation should make an upper limit 0.0005% of the weight of addition, and this], the remarkable thing has checked clearly the improvement effectiveness of the grain boundary reinforcement of B addition steel which artificers have checked conventionally. And in the technique to precede, it came to check that the addition of B arises, and the crack has all arisen depending on slab heating conditions at the time of hot rolling since it is abundant, 0.0005% or more and.
[0013] Based on the above knowledge, as this invention persons are the range which does not degrade the hot-working nature and controlled the amount of B added to austenitic stainless steel within fixed limits, they completed a header and this invention for the stainless steel excellent in high temperature strength and hot-working nature.
[0014] That is, this invention can offer the stainless steel which has high high temperature strength and was

excellent in cracking resistance in hot working for the purpose of reduction of the manufacture yield or a manufacturing cost by limiting a steel presentation to the following range.

[0015] The reason for component addition and the reason for component limitation of this invention are explained below.

(1) Since sufficient improvement in high temperature strength is not obtained unless it adds 0.04% or more, but heat slowing nature will be injured on the other hand if it adds exceeding 0.15% although it is the element which is useful to the improvement in grain boundary on the strength of the component presentation range steel of C:0.04 - 0.15%, and raises high temperature strength, an addition is 0.04 - 0.15%.

[0016] Si: Although effectiveness is in deoxidation 2% or less and hot-working nature is raised through O reduction in steel, since the cracks after rolling will come to occur frequently if it adds exceeding 2%, an addition is 2% or less.

[0017] Mn: Although it works effectively as an austenite stabilization element in stainless steel 3% or less, since ductility will fall if it adds exceeding 3%, an addition is 3% or less.

[0018] It is the element most harmful to S:0.003% or less hot-working nature, and a content is so good that it is low. Since heat slowing nature is permissible if it is 0.003% or less, a content is 0.003% or less.

[0019] It is the element which injures hot-working nature P:0.07% or less, and a content is so good that it is low. Since heat slowing nature is permissible if it is 0.07% or less, a content is 0.07% or less.

[0020] It is the element which injures hot-working nature O:0.004% or less, and a content is so good that it is low. Since heat slowing nature is permissible if it is 0.004% or less, a content is 0.004% or less.

[0021] nickel: -- it is the stabilization element of an austenite phase powerful 5 to 25%, and the ductility of steel is raised generally. By the target component system, 5% or more needs to be added for stabilization of an inphase here. On the other hand, since an inphase will become too stable, extent of the grain boundary segregation of elements, such as S, harmful P, harmful O, etc., will become remarkably large and it will result in spoiling hot-working nature if it adds exceeding 25%, an addition is 5 - 25%.

[0022] Cr: It is the fundamental component of 13 - 35% stainless steel, and is effective on a hot anti-oxidation disposition. If it does not add 13% or more, as a result of there being scale at the time of heating at high temperature along a grain boundary and developing into the interior remarkably, the crack at the time of hot working will also become remarkable. On the other hand, if it adds exceeding 35%, since it will become difficult to hold an organization in austenite single phase and it will become easy to generate the crack at the time of processing too in an interface with the ferrite phase which deposited, an addition is 13 - 35%.

[0023] aluminum: Although effectiveness is in deoxidation like Si 0.006 to 0.03% and hot-working nature is raised through O reduction in steel, since the streak flaws after rolling will come to occur frequently if effectiveness is not enough unless it adds 0.006% or more, and it adds exceeding 0.03% conversely, an addition is 0.006 - 0.03%.

[0024] An austenite phase is stable N:0.3% or less with addition. Since an inphase will become too stable, extent of the grain boundary segregation of elements, such as S, harmful P, harmful O, etc., will become remarkably large and it will result in spoiling hot-working nature if it is the same as that of the case of nickel and adds exceeding 0.3%, an addition is 0.3% or less.

[0025] Control of an addition is just going to consider as the chief aim of this invention as mentioned above B:0.0002 to 0.0005%. Although the content contained as an impurity in the usual steel manufacture is about 0.0001%, the effectiveness of 0.0002% or more of content, then crystal stressing shows up enough. On the other hand, if contained exceeding 0.0005%, since it will become easy to produce the compound of the low melting point in a grain boundary and a crack will be produced depending on heating conditions at the time of rolling, a content is restricted to 0.0002 - 0.0005%.

[0026] Mo: 1.5% or more which is an element effective in the corrosion-resistant improvement in steel and by which the effectiveness is demonstrated 1.5 to 4%, it is 4% or less of range which the crack at the time of rolling by the self-segregation does not generate, and selection addition is possible.

[0027] Since each of Nb(s), and Ti, V and Zr form carbide powerfully Zr<=1.2% and the high temperature strength of steel is raised rather than the case where C is only added, through carbide dispersion strengthening Nb<=1.2%, Ti<=0.6%, and V<=0.6%, the selection addition even of the four kinds can be carried out more than a kind. If it adds exceeding 1.2%, 0.6%, 0.6%, and 1.2%, respectively, since an intermetallic compound harmful at the time of heating use will generate and high temperature strength will be reduced, an addition is less than [Zr:1.2%] less than [Nb:1.2%], less than [Ti:0.6%], and V:0.6% or less.

[0028] By adjusting to the above-mentioned component presentation range, it becomes possible to obtain the stainless steel excellent in high temperature strength and hot-working nature. In addition, about manufacture conditions, it is not limited especially by this invention. Namely, the ingot approach of stainless steel, the rolling approach at the time of steel plate manufacture, and the heat treatment approaches should just be conditions usually adopted. The example of this invention is given to below and the effectiveness of this invention is proved.

[Translation done.]

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3.In the drawings, any words are not translated.

EXAMPLE

[Example] Table 1 makes the chemical entity, high temperature strength, and hot-working nature (at the time of rolling the surface crack number, lug crack die length) of comparison steel (No.33-61) this invention steel (No.1-32), and Table 2 makes them a list.
[0030] Experimental reactor vacuum melting of each steel was carried out, and it used the obtained steel ingot as sample offering steel according to the process of 1250-degree-C heating slabbing and finishing rolling, and annealing. Slabbing evaluated hot-working nature by considering as 20% or more of large pressing-down rolling 3 pass, and carrying out direct observation of the front face/the end face of the slab after rolling. That is, the surface crack including a streak flaw was counted focusing on the slab latest section, and was evaluated as the crack number per unit surface area, and the lug crack and edge crack die length further produced at the edge were measured as the depth from an edge.
[0031] About high temperature strength, at a broth (diameter [of the parallel part dimension of 6mm] x30mm die length), and 600 degrees C, the creep rupture test piece was deleted from the plate center section after finishing rolling in the direction of L, and the creep rupture trial of 2-several was carried out, and it interpolated or extrapolated and asked for fracture strength for 1000 hours.
[0032] This invention steel No.1-No.32 are excellent in good high temperature strength and coincidence a pressure-proof total at hot-working nature, such as crack nature, compared with the comparison steel mentioned later. these -- receiving -- comparison steel No.34 -- C and comparison steel No.35 -- Si and comparison steel No.36 -- Mn and comparison steel No.37 -- P and comparison steel No.39 -- O and comparison steel No.41 -- nickel and comparison steel No.43 -- Cr and comparison steel No. -- the content of 46 andN has exceeded the range of this invention default value, and 54 are inferior in hot-working nature as compared with this invention steel. Moreover, when the content of B has exceeded the range of this invention default value like comparison steel No.47, and 55 and 56, while a lug crack increases, it also turns out that lack arises to heat slowing nature too only by additive-free impurity level being included like comparison steel No.48. The relation between B content and lug crack die length is shown in drawing 1 .
[0033] On the other hand, comparison steel No.33 run short of C, and good high temperature strength is not obtained. Comparison steel No.38 have the superfluous content of S, and as compared with this invention steel, high temperature strength is inferior in them too as a result of the fall of elevated-temperature ductility of long duration. Moreover, comparison steel No.40 run short of the amounts of nickel, and an organization does not become an austenite, but high temperature strength is low. Comparison steel No.42 caused promotion of a ruptured, as a result of the amounts of Cr(s) running short and receiving high temperature oxidation with a remarkable creep rupture test piece front face. Naturally, high temperature strength is low. It Nb(s). comparison steel No.49 [furthermore,] -- Mo and comparison steel No. -- 50 and 57 comparison steel No. -- 51 and 58 -- Ti and comparison steel No. -- 52, 59V, and comparison steel No. -- 53 and 60 -- Zr -- As a result of the content of Nb and Ti having exceeded the range of this invention default value and causing self-segregation or a deposit of a weak intermetallic compound, as compared with this invention steel, hot-working nature or high temperature strength is inferior in comparison steel No.61. comparison steel No. -- since 44 and 45 had the respectively insufficient or superfluous amount of aluminum, in lug crack generating and the latter which are depended insufficiently [the former / deoxidation], streak flaw increase of an oxide reason was conspicuous. The streak flaw number also increases sharply the case of the above-mentioned overSi of comparison steel No.35, and overO of comparison steel No.39, and it is presumed that it is an oxide reason.
[0034] Taking correspondence with the above laboratory examination, it carried out about 6 charge and the prototype of a real production line evaluated hot-working nature (manufacturability) about two items of high

temperature strength, and a surface crack and a lug crack. A result is collectively shown in Table 3. In No.70 of Table 3, No.71, and No.72, this invention steel, No.73, No.74, and No.75 are comparison steel.

[0035] Each this invention steel No.70-72 has good high temperature strength, and a surface crack is five pieces/m2. It was the following and the lug crack was the level which is 5mm or less and can carry out care-and-cleaning removal easily from an edge.

[0036] On the other hand, more greatly [the amount of B] than the fitness range, since comparison steel No.74 were lower than the fitness range, as for all, many surface cracks arose and the lug crack also had [comparison steel No.73] a deep inclination. The relation between the amount of B and lug crack die length is shown in drawing 2 . Furthermore, since comparison steel No.75 have the amount of C lower than the fitness range, high temperature strength is inferior in them.

[0037] In addition, 6 charges of real manufacture used the slab cross section of 250x1700 (mm) by the large-sized continuous casting machine system-ized recently. In order to obtain the hot-working nature and high temperature strength which are meant by this invention so that it may illustrate above, he specifies the content of each alloy element by which it is characterized by this invention, and it is understood that it is required to manage especially the amount of B strictly.

[0038]

[Table 1]

表 1

区分	No.	化学成分 (重量%)								
		C	Si	Mn	P	S	O	Ni	Cr	sol. Al
本発明鋼	1	0.05	0.59	1.25	0.036	0.002	0.0030	8.42	17.85	0.011
	2	0.04	0.65	1.04	0.028	0.002	0.0025	10.52	18.06	0.008
	3	0.14	0.51	1.08	0.022	0.001	0.0028	8.30	18.11	0.009
	4	0.06	1.70	1.34	0.030	0.001	0.0027	8.09	18.04	0.010
	5	0.05	0.44	2.51	0.019	0.001	0.0024	7.95	18.10	0.007
	6	0.05	0.65	1.26	0.065	0.002	0.0021	12.03	18.24	0.007
	7	0.05	0.60	1.15	0.015	0.003	0.0019	12.05	18.09	0.009
	8	0.08	0.53	1.10	0.016	0.002	0.0040	11.55	18.13	0.009
	9	0.05	0.58	1.34	0.022	0.003	0.0033	6.00	16.19	0.018
	10	0.07	0.57	1.19	0.041	0.001	0.0035	23.20	17.96	0.016
	11	0.05	0.46	1.23	0.036	0.002	0.0030	5.68	14.82	0.022
	12	0.07	0.64	1.20	0.033	0.001	0.0028	21.00	25.30	0.019
	13	0.07	0.47	1.55	0.032	0.002	0.0027	24.30	32.90	0.025
	14	0.06	0.52	1.02	0.027	0.002	0.0015	9.42	17.82	0.006
	15	0.06	0.55	1.18	0.026	0.001	0.0011	9.31	17.80	0.029
	16	0.05	0.55	1.07	0.040	0.002	0.0033	9.38	17.96	0.014
	17	0.06	0.61	1.07	0.024	0.002	0.0036	8.99	17.93	0.012
	18	0.05	0.67	1.03	0.016	0.001	0.0034	8.76	17.88	0.011
	19	0.05	0.59	1.10	0.033	0.001	0.0032	8.80	17.69	0.017
	20	0.06	0.58	1.28	0.035	0.001	0.0039	12.04	18.03	0.015
	21	0.07	0.69	1.27	0.031	0.002	0.0024	11.68	18.00	0.020
	22	0.06	0.81	1.24	0.030	0.001	0.0035	11.84	18.01	0.016
	23	0.07	0.82	1.25	0.026	0.002	0.0034	11.37	18.10	0.017
	24	0.07	0.44	1.33	0.025	0.001	0.0029	10.06	18.27	0.013
	25	0.05	0.49	1.36	0.020	0.001	0.0026	10.38	17.68	0.023
	26	0.06	0.55	1.15	0.031	0.002	0.0017	8.25	18.01	0.019
	27	0.05	0.47	1.04	0.019	0.002	0.0026	8.33	18.06	0.012
	28	0.06	0.44	1.09	0.017	0.001	0.0015	8.46	18.10	0.009
	29	0.06	0.39	1.07	0.026	0.001	0.0030	8.31	18.04	0.008
	30	0.07	0.36	1.03	0.022	0.001	0.0017	8.72	18.05	0.016
	31	0.06	0.48	1.08	0.025	0.003	0.0018	8.99	18.07	0.017
	32	0.06	0.47	1.11	0.024	0.002	0.0022	8.62	17.89	0.014

[0039]

[Table 2]

表　1（つづき）

区分	No.	化学成分（重量%）						
		N	B	Mo	Nb	Ti	V	Zr
本発明鋼	1	0.007	0.0004	0.04	0.00	0.00	0.00	0.00
	2	0.003	0.0002	0.03	0.00	0.00	0.00	0.00
	3	0.004	0.0003	0.03	0.00	0.00	0.00	0.00
	4	0.011	0.0005	0.02	0.00	0.00	0.00	0.00
	5	0.009	0.0004	0.02	0.00	0.00	0.00	0.00
	6	0.008	0.0004	0.02	0.00	0.00	0.00	0.00
	7	0.010	0.0005	0.03	0.00	0.00	0.00	0.00
	8	0.007	0.0002	0.03	0.00	0.00	0.00	0.00
	9	0.009	0.0002	0.04	0.00	0.00	0.00	0.00
	10	0.014	0.0003	0.03	0.00	0.00	0.00	0.00
	11	0.012	0.0005	0.04	0.00	0.00	0.00	0.00
	12	0.011	0.0005	2.40	0.00	0.00	0.00	0.00
	13	0.006	0.0004	2.40	0.00	0.00	0.00	0.00
	14	0.008	0.0003	2.40	0.00	0.00	0.00	0.00
	15	0.010	0.0004	0.04	0.00	0.00	0.00	0.00
	16	0.244	0.0004	0.05	0.00	0.00	0.00	0.00
	17	0.154	0.0005	0.03	0.00	0.00	0.00	0.00
	18	0.162	0.0005	0.02	0.00	0.00	0.00	0.00
	19	0.002	0.0005	0.04	0.00	0.00	0.00	0.00
	20	0.006	0.0005	1.80	0.00	0.00	0.00	0.00
	21	0.004	0.0003	2.43	0.00	0.00	0.00	0.00
	22	0.008	0.0004	3.56	0.00	0.00	0.00	0.00
	23	0.003	0.0004	0.05	0.87	0.00	0.00	0.00
	24	0.007	0.0003	0.04	0.00	0.44	0.00	0.00
	25	0.002	0.0002	0.03	0.00	0.00	0.39	0.00
	26	0.006	0.0004	0.05	0.00	0.00	0.00	0.65
	27	0.001	0.0004	0.34	0.21	0.15	0.00	0.00
	28	0.004	0.0003	2.43	0.74	0.00	0.00	0.00
	29	0.003	0.0002	2.48	0.51	0.38	0.00	0.00
	30	0.002	0.0003	2.36	0.44	0.00	0.21	0.00
	31	0.002	0.0005	2.39	0.26	0.25	0.12	0.00
	32	0.005	0.0004	2.51	0.34	0.20	0.14	0.37

[0040]
[Table 3]

表　1（つづき）

区分	No.	高温強度	圧延時表面疵	圧延時耳割れ
		600℃1000hクリープ破断強さ（MPa）	疵個数（個／m^2）	エッジからの深さ（mm）
本発明鋼	1	205	4	0.0
	2	184	4	0.0
	3	268	0	0.0
	4	197	2	0.0
	5	186	1	0.0
	6	245	3	0.0
	7	203	3	0.0
	8	200	7	0.0
	9	172	0	0.0
	10	228	4	0.0
	11	174	2	0.5
	12	231	3	0.0
	13	213	0	0.3
	14	210	0	0.0
	15	218	4	0.0
	16	324	1	0.0
	17	306	0	0.0
	18	308	0	0.0
	19	234	2	0.0
	20	227	0	0.0
	21	263	0	0.0
	22	266	3	0.0
	23	310	0	0.0
	24	295	2	0.0
	25	275	5	0.0
	26	260	0	0.0
	27	315	1	0.0
	28	322	4	0.0
	29	330	0	0.0
	30	301	3	0.0
	31	316	0	0.0
	32	289	0	0.0

[0041]
[Table 4]

表　2

区分	No.	化学成分（重量%）								
		C	Si	Mn	P	S	O	Ni	Cr	sol. Al
比較鋼	33	0.03*	0.55	1.07	0.024	0.001	0.0026	8.23	17.45	0.011
	34	0.17*	0.57	1.24	0.026	0.001	0.0031	8.45	18.02	0.008
	35	0.07	2.4 *	1.13	0.023	0.001	0.0021	8.16	18.87	0.009
	36	0.06	0.89	3.84*	0.041	0.002	0.0019	8.17	19.03	0.010
	37	0.06	0.91	1.16	0.102*	0.001	0.0017	8.20	18.11	0.007
	38	0.07	0.68	1.09	0.039	0.005*	0.0028	10.65	17.36	0.007
	39	0.06	0.67	1.06	0.028	0.002	0.0140*	10.10	17.94	0.009
	40	0.05	0.60	1.08	0.027	0.002	0.0031	3.55*	18.10	0.009
	41	0.05	0.62	1.08	0.019	0.001	0.0017	25.50*	18.52	0.018
	42	0.05	0.59	1.17	0.014	0.001	0.0027	10.04	11.05*	0.016
	43	0.04	0.63	1.22	0.026	0.003	0.0027	25.00	35.51*	0.022
	44	0.07	0.66	1.27	0.029	0.003	0.0026	10.13	17.89	0.004*
	45	0.06	0.67	1.23	0.035	0.001	0.0028	9.35	17.25	0.044*
	46	0.08	0.65	1.20	0.037	0.001	0.0030	9.33	17.88	0.006
	47	0.06	0.54	1.02	0.030	0.003	0.0014	9.41	18.14	0.029
	48	0.05	0.53	1.11	0.020	0.002	0.0018	9.50	18.26	0.014
	49	0.05	0.48	1.17	0.018	0.002	0.0029	9.28	18.75	0.012
	50	0.07	0.57	1.13	0.028	0.002	0.0027	12.03	17.34	0.011
	51	0.06	0.55	1.05	0.036	0.001	0.0011	12.04	17.55	0.017
	52	0.07	0.53	1.09	0.037	0.002	0.0030	12.05	18.65	0.015
	53	0.07	0.52	1.50	0.027	0.001	0.0025	12.01	19.12	0.020
	54	0.06	0.59	1.03	0.029	0.002	0.0023	12.18	21.03	0.016
	55	0.05	0.51	1.14	0.021	0.001	0.0021	12.16	20.00	0.017
	56	0.06	0.48	1.47	0.025	0.001	0.0013	12.04	23.05	0.013
	57	0.06	0.53	1.25	0.038	0.001	0.0018	12.07	18.03	0.023
	58	0.07	0.60	1.00	0.037	0.002	0.0027	12.05	18.47	0.019
	59	0.06	0.49	1.03	0.018	0.002	0.0025	10.35	17.44	0.012
	60	0.07	0.51	0.97	0.017	0.002	0.0025	9.30	16.59	0.009
	61	0.07	0.57	1.90	0.017	0.001	0.0016	8.31	16.23	0.008

注）＊印は本発明の範囲から外れていることを表す。

[0042]
[Table 5]

表　2（つづき）

区分	No.	化学成分（重量%）						
		N	B	Mo	Nb	Ti	V	Zr
比較鋼	33	0.005	0.0002	0.03	0.00	0.00	0.00	0.00
	34	0.004	0.0003	0.02	0.00	0.00	0.00	0.00
	35	0.003	0.0003	0.03	0.00	0.00	0.00	0.00
	36	0.009	0.0005	0.04	0.00	0.00	0.00	0.00
	37	0.011	0.0004	0.03	0.00	0.00	0.00	0.00
	38	0.010	0.0003	0.03	0.00	0.00	0.00	0.00
	39	0.006	0.0002	0.03	0.00	0.00	0.00	0.00
	40	0.004	0.0004	0.02	0.00	0.00	0.00	0.00
	41	0.010	0.0004	0.04	0.00	0.00	0.00	0.00
	42	0.016	0.0004	0.04	0.00	0.00	0.00	0.00
	43	0.014	0.0003	0.03	0.00	0.00	0.00	0.00
	44	0.007	0.0005	0.03	0.00	0.00	0.00	0.00
	45	0.008	0.0004	0.02	0.00	0.00	0.00	0.00
	46	0.320*	0.0003	0.03	0.00	0.00	0.00	0.00
	47	0.016	0.0009*	0.04	0.00	0.00	0.00	0.00
	48	0.020	0.0001*	0.03	0.00	0.00	0.00	0.00
	49	0.009	0.0005	4.5*	0.00	0.00	0.00	0.00
	50	0.003	0.0005	0.01	1.25 *	0.00	0.00	0.00
	51	0.007	0.0003	0.02	0.00	0.75 *	0.00	0.00
	52	0.006	0.0004	0.01	0.00	0.00	0.77 *	0.00
	53	0.002	0.0002	0.03	0.00	0.00	0.00	1.43 *
	54	0.315*	0.0003	2.32	0.00	0.00	0.00	0.00
	55	0.016	0.0034*	2.41	0.00	0.00	0.00	0.00
	56	0.013	0.0017*	2.40	0.00	0.00	0.00	0.00
	57	0.021	0.0003	2.36	1.22 *	0.00	0.00	0.00
	58	0.007	0.0002	2.28	0.00	0.68 *	0.00	0.00
	59	0.004	0.0004	2.35	0.00	0.00	0.72 *	0.00
	60	0.005	0.0003	2.20	0.00	0.00	0.00	1.35 *
	61	0.009	0.0002	2.14	1.29 *	0.77 *	0.00	0.00

注）＊印は本発明の範囲から外れていることを表す。

[0043]
[Table 6]

表　2（つづき）

区分	No.	高温強度	圧延時表面疵	圧延時耳割れ
		600℃1000hクリープ破断強さ (MPa)	疵個数 (個/m^2)	エッジからの深さ (mm)
比較鋼	33	134*	2	0.0
	34	234	3	5.3
	35	203	84	1.3
	36	178	1	2.2
	37	243	0	2.9
	38	146*	0	4.0
	39	198	29	1.8
	40	147*	3	0.0
	41	210	0	3.2
	42	133*	2	10.7
	43	206	3	3.3
	44	211	0	1.6
	45	215	57	1.0
	46	343	3	3.8
	47	228	0	2.0
	48	254	1	1.6
	49	260	3	2.9
	50	142*	2	0.0
	51	138*	2	0.0
	52	110*	0	0.0
	53	117*	4	0.0
	54	304	6	4.1
	55	249	2	3.7
	56	241	2	2.6
	57	139*	3	0.0
	58	115*	0	0.0
	59	116*	0	0.0
	60	108*	4	0.0
	61	103*	0	0.0

注）＊印は標準的な本発明鋼より５０ＭＰａ以上低強度であることを表す。

[0044]
[Table 7]

表　3

区分	No.	化学成分 (重量%)								
		C	Si	Mn	P	S	O	Ni	Cr	sol. Al
本発明鋼	70	0.12	0.50	1.02	0.025	0.001	0.0033	8.21	18.07	0.008
	71	0.06	1.45	1.00	0.021	0.001	0.0034	8.10	18.05	0.009
	72	0.05	0.43	1.68	0.020	0.002	0.0040	8.08	18.03	0.008
比較鋼	73	0.05	0.51	1.00	0.032	0.002	0.0029	8.06	18.10	0.009
	74	0.04	0.50	1.12	0.028	0.003	0.0041	8.01	18.07	0.009
	75	0.02*	0.52	1.04	0.019	0.001	0.0040	8.03	18.11	0.012

注）＊印は本発明の範囲から外れていることを表す。

[0045]
[Table 8]

表　3（つづき）

区　分	No.	化学成分（重量%）						
		N	B	Mo	Nb	Ti	V	Zr
本発明鋼	70	0.005	0.0005	0.05	0.00	0.00	0.00	0.00
	71	0.009	0.0003	0.03	0.00	0.00	0.00	0.00
	72	0.007	0.0003	0.03	0.00	0.00	0.00	0.00
比較鋼	73	0.006	0.0010*	0.02	0.00	0.00	0.00	0.00
	74	0.015	0.0001*	0.02	0.00	0.00	0.00	0.00
	75	0.008	0.0004	0.03	0.00	0.00	0.00	0.00

注）＊印は本発明の範囲から外れていることを表す。

[0046]
[Table 9]

表　3（つづき）

区　分	No.	高温強度	圧延時表面疵	圧延時耳割れ
		600 ℃×1000時間 クリープ破断強さ(MPa)	疵個数（個／m^2）	エッジからの深さ(mm)
本発明鋼	70	280	1	0.0
	71	203	4	0.0
	72	179	3	0.0
比較鋼	73	236	6 *	6.0 *
	74	238	15 *	5.5 *
	75	120 *	4	0.0

注）＊印は本発明の範囲から外れていることを表す。

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Drawing showing the relation between B content and the lug crack die length at the time of hot rolling.
[Drawing 2] Drawing showing the relation between B content in the production line of continuous casting material, and lug crack die length.

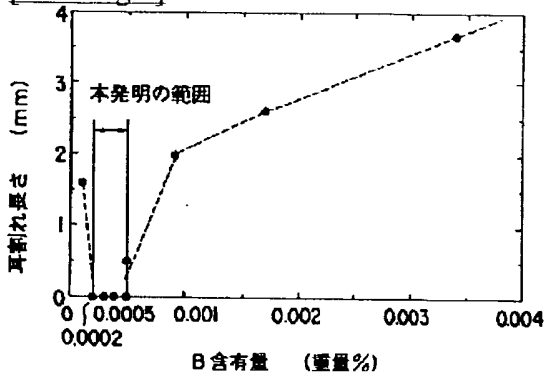
[Translation done.]

* NOTICES *

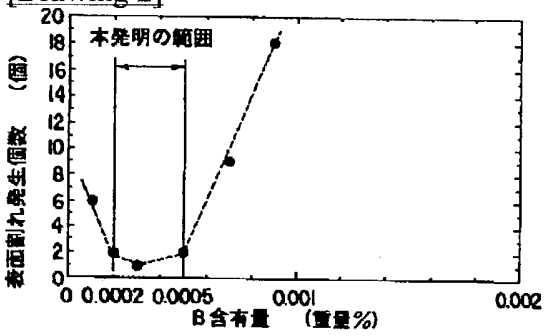
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

[Drawing 1]



[Drawing 2]



[Translation done.]